USGS

Sound Waves

Coastal and Marine Research News from Across the USGS

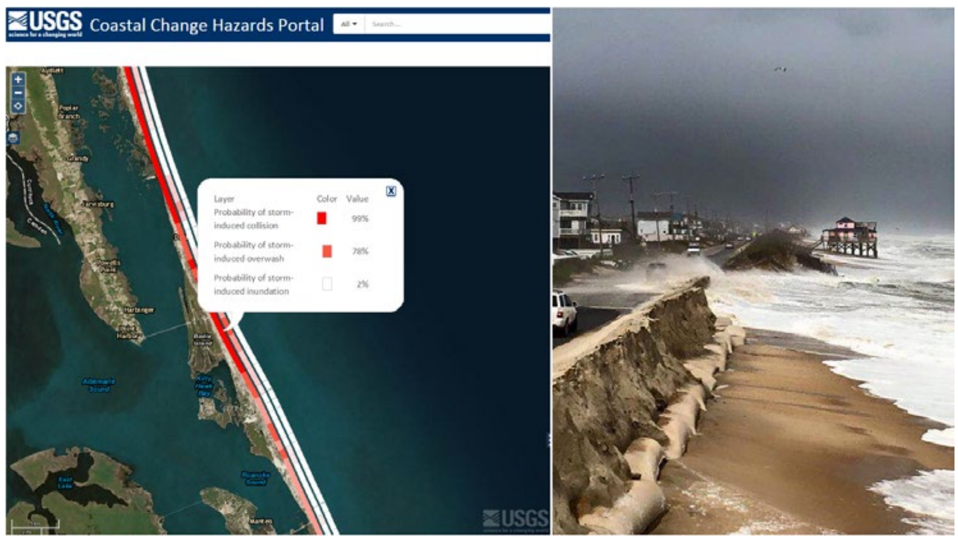
http://soundwaves.usgs.gov/

Research

This Hurricane Season, Scientists Bring Wave Action into the Picture

By Hillary Stockdon, Joe Long, and Heather Dewar

[Slightly modified from USGS National News Release (***https://www.usgs.gov/news/hurricane-season-scientists-bring-wave-action-picture***).]



As a USGS model predicted (left), Hurricane Joaquin overwashed this Kitty Hawk, North Carolina, road in 2015 (right).

This hurricane season weather forecasters, emergency managers, and coastal residents have access to tools developed by the USGS that predict, more precisely than ever, where beach erosion and beachfront flooding will take place during hurricanes and other storms.

These potentially life-saving coastal change forecasts are publicly available online for beaches within a hurricane's predicted strike zone approximately 36 hours before the storm makes landfall. And in a pilot program beginning this year, emergency managers and forecasters in areas of coastal Florida, North Carolina, and Massachusetts will have access to hour-by-hour predictions of potential beachfront changes brought on by hurricanes, Nor'easters, and lesser storms.

"This year coastal residents can get specific information about likely impacts from an approaching storm, like where erosion will occur, whether sand dunes will be inundated by storm surge, and how high water levels are expected to be at the shoreline," said USGS research oceanographer **Hilary Stockdon**, who led the development of these forecasting tools.

While most people think of hurricanes as massive wind and rain storms, "storm surge and large waves pose the greatest threat to life and property along the coast," according to the National Hurricane Center's hazards summary. Beaches are important natural barriers against damaging waves, but their capacity to protect coastal communities varies, depending on local coastal conditions and each storm's characteristics.

The USGS coastal change forecast model works with information from the National Hurricane Center's storm surge predictions and NOAA wave forecast models, which describe storm wave heights and the timing between them. The USGS model adds information about the beach slope and predicts how far a storm's large waves will push water up the beach. "That allows us to predict whether water levels will overtop dunes, whether ocean water will inundate areas behind the beachfront, and whether barrier islands will breach," said USGS research oceanographer **Joseph Long**, a member of the team working on the models.

In 2015 the USGS began providing emergency managers and citizens with detailed information from the coastal change forecast developed by Stockdon and others. The forecast provides information for Gulf and Atlantic sandy beaches every kilometer (just under two-thirds of a mile). When a hurricane is expected to strike the U.S. coast, the model shows three types of likely impacts—beach erosion, dune overwash, and coastal inundation—for the predicted area of landfall. The USGS Coastal Change Hazards Portal (**http://marine.usgs.gov/coastalchangehazardsportal/**) makes that information easily accessible to the public when a storm is approaching. It also offers scenarios for those same three types of coastal change if hypothetical hurricanes ranging from Category 1 to Category 5 make landfall anywhere along the U.S. Atlantic or Gulf coasts.

A new version of the coastal change forecast model, which Long is developing and testing with the National Weather Service, can make the same types of predictions up and down the coast at a scale of 300 meters, or about two-tenths of a mile. It also runs continuously, so it can predict beach changes under all sorts of weather conditions, including on calm days.

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Sound Waves

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Submission Guidelines

Deadline: The deadline for news items and publication lists for the September issue of *Sound Waves* is Wednesday, August 17, 2016.

Publications: When new publications or products are released, please notify the editor with a full reference and a bulleted summary or description.

Images: Please submit all images at publication size (column, 2-column, or page width). Resolution of 200 to 300 dpi (dots per inch) is best. Adobe Illustrator© files or EPS files work well with vector files (such as graphs or diagrams). TIFF and JPEG files work well with raster files (photographs or rasterized vector files).

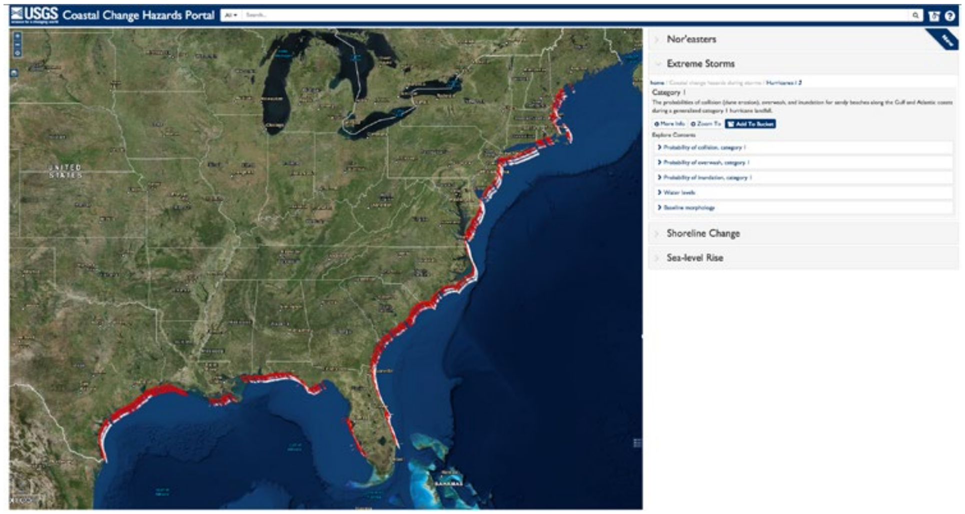
U.S. Geological Survey
Earth Science Information Sources:

Need to find natural-science data or information? Visit the USGS Frequently Asked Questions (FAQ's) at URL http://www.usgs.gov/faq/

Can't find the answer to your question on the Web? Call 1-888-ASK-USGS

Want to e-mail your question to the USGS? Send it to this address: ask@usgs.gov

(Wave Action continued from page 1)



This screenshot of the USGS Coastal Change Hazards Portal shows potential weather-induced coastal changes along the Atlantic and Gulf coasts.

Along a frequently eroded or overwashed beach near Kitty Hawk, North Carolina, USGS and U.S. Army Corps of Engineers scientists are using two video cameras and a laser-measuring device to field test and refine hourly predictions of a storm's effects. During an April storm, the model predicted that waves could carry sand onto a beachfront road behind the dunes, Long said. The prediction was confirmed when the video cameras captured the overwash and sand covering the roadway as they happened.

To supplement the video cameras providing real-time information along the North Carolina beach, Long hopes to install beach cameras on the northeast coast of Massachusetts, in Jupiter, Florida, and on the Gulf of Mexico at Tampa Bay. A Tampa Bay camera is ready to go and the researchers are currently seeking a beachfront building whose owner will allow them to install it.

"Once we install the camera and survey the beach, every pixel on every image becomes a measuring device for tracking change," Long said. "We can learn from these small areas, test our models, and build that into our national forecasts."

"Our goal is to be able to provide the best possible forecasts of the vulnerability of our coasts and communities nationwide. The pilot projects will help us test our understanding and determine how best to do that," said **John Haines**, USGS Coastal and Marine Geology Program Coordinator.

Congressional funding provided after Hurricane Sandy in 2012 supports USGS advances in predicting coastal change. "This kind of information is aimed at improving emergency preparedness and response," said Haines, "It is a good example of our efforts to deliver coastal change science that makes our coasts safer and more resilient." ☸

This USGS towable storm tower was set up in early April 2016 at Kitty Hawk, North Carolina, in collaboration with the U.S. Army Corps of Engineers. This was the first test of this mobile storm-tracking tower, which uses cameras and lidar to track wave patterns. The USGS hopes the mobility of these towers will allow them to be placed in the paths of future storms.

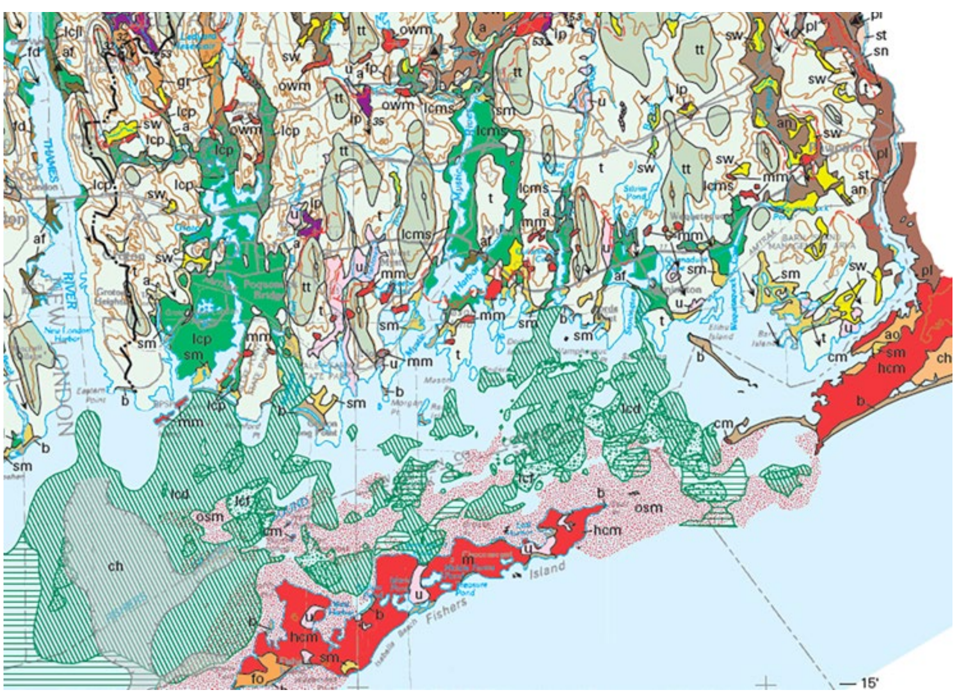
New Quaternary Geology Map Reuses Decades-Old USGS Data

By Fran Lightsom

Since 1879, the USGS has been mapping the geologic composition and structure of the United States. In New England this effort has included mapping the effects of continental glaciation during the Quaternary Period (the last 2.6 million years), which shaped the landscape and left behind extensive deposits of glacial till and distinctive features like moraines and outwash plains. During these “ice ages,” which ended about 14,000 years ago, sea level was considerably lower than it is at present, and glaciers advanced beyond the current shoreline onto the exposed continental shelf. When the glaciers subsequently retreated and sea level rose again, evidence of glaciation remained on the shelf but became concealed by coastal waters. However, these “drowned” glacial deposits and associated features are no different in origin than their counterparts on dry land, and a full understanding of the glacial history of the area requires both traditional geologic mapping (**http://ncgmp.usgs.gov/geomaps/introgeo_mapping.html**) and the shipboard techniques employed by marine geologists to map the sea floor (**http://woodshole.er.usgs.gov/operations/sfmapping/**). Because of the complex interplay of continental glaciation and sea level, a complete map of the Quaternary deposits in New England needs to extend beyond the current shoreline.

For the past several years, the USGS Eastern Geology and Paleoclimate Science Center has been working to produce a new Quaternary geologic map for Massachusetts and adjacent offshore areas based on new understandings of glacier dynamics and now-submerged glacial lake deposits. USGS geologist **Janet Stone** and **Ralph Lewis**, a marine geologist at the University of Connecticut, are producing the new map with the help of USGS geologist **Mary DiGiacomo-Cohen**. The team previously published a similar map that integrates the terrestrial geology of Connecticut with the offshore geology of Long Island Sound. The new Massachusetts map will incorporate all available offshore data (more than 20,000 line-kilometers of high-resolution seismic-reflection profiles), including data that were collected in the 1970s by scientists at the USGS Woods Hole office: **Charles O’Hara**, **James Robb**, **Robert Oldale**, **David Twichell**, **William Dillon**, and **Harley Knebel**. In addition, all of the newer USGS data (collected since 2005) have been analyzed during the map compilation.

*The previous map of Massachusetts Quaternary geology, published in 1991, truncates features at the coastline. The 1991 map is online in the National Geologic Map Database (**http://ngmdb.usgs.gov/Prodesc/proddesc_9221.htm**).*



*This 2005 Connecticut map, like the new Massachusetts map that is being produced, shows the continuation of Quaternary geological features from onshore to offshore. The Connecticut map is USGS Scientific Investigations Map 2784 (**http://pubs.usgs.gov/sim/2005/2784/**).*

In December 2015, **Ralph Lewis** contacted **Linda McCarthy**, data librarian at the USGS Woods Hole Coastal and Marine Science Center, inquiring about access to original seismic-reflection data from seven field activities during the 1970s. When Stone, Lewis, and DiGiacomo-Cohen arrived in Woods Hole on January 13, 2016, McCarthy had pulled out the long paper charts of interest, and USGS geologist **VeeAnn Cross** was on hand to assist with digitizing data and compiling accompanying metadata. The group scanned 50 seismic records, seven track-charts, and two navigation logbooks, which will be added to the data library website (**http://woodshole.er.usgs.gov/operations/ia/**) for use by other projects. In addition, the project team was provided with nine compact disks containing previously digitized data. Stone later observed that the 1970s data “is proving to be extremely useful, and we very much appreciate the fact that we were able to access these important data. Given today’s funding realities, there is next to no chance that new data of this quality will become available. The data library is a treasure trove for workers like us!” ☸

Updated Website Provides Easy Access to Oceanographic Time-Series Data

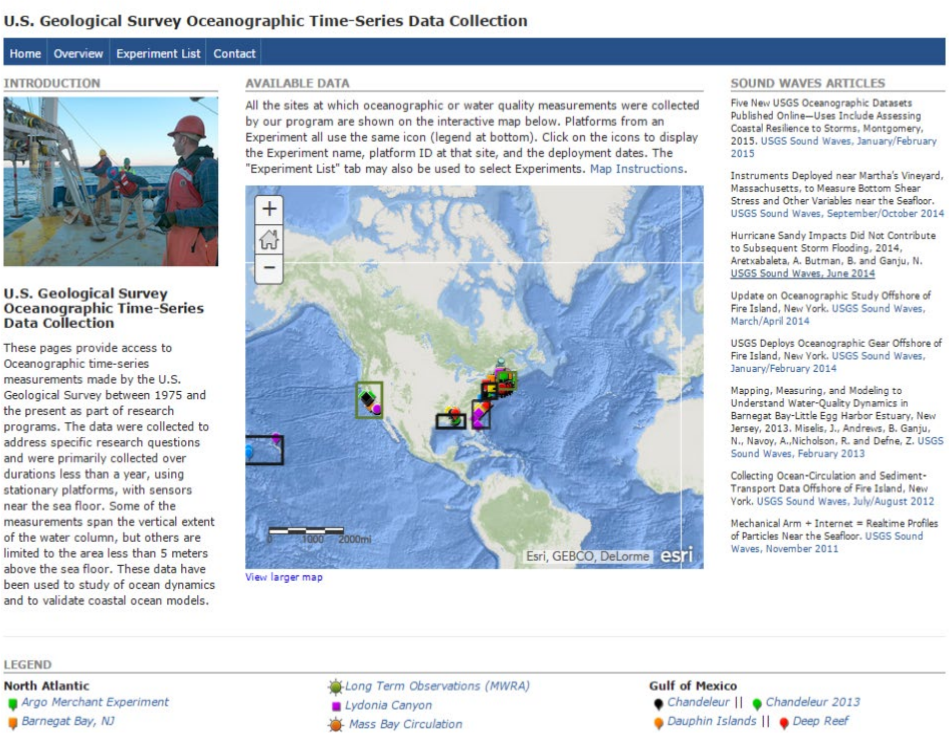
By Ellyn Montgomery

USGS Coastal and Marine Geology Program oceanographic and estuarine measurements have been available online since 2007, but an updated interface (**http://stellwagen.er.usgs.gov**) makes browsing and identifying datasets of interest significantly easier and faster.

The data were collected during USGS Coastal and Marine Geology Program circulation and sediment transport studies and include measurements of currents, waves, water quality, light attenuation, and turbidity from many locations. The data support research for various circulation and sediment transport studies, including the effects of Hurricane Sandy and other coastal storms..

The website home page (see figure below) features an interactive map that allows users to easily browse the data holdings, identify sites of interest, and view the types of data included in each dataset. Boxes on the map indicate regional groupings of the experiments. A legend of experiment names and icons is below the map. Links to recent articles about the research are provided to the right of the map; selected publications associated with the data are provided on each experiment's description page. A horizontal navigation bar above the map provides navigation between sections.

The "Overview" tab links to background information about the contents and formats of the data holdings and a link to the report by Montgomery and others (2016, **http://woodshole.er.usgs.gov/pubs/of2007-1194/)** that provides detailed documentation about the process required for data to be released in the collection. The report was updated in 2016 to document usage of the new web interface, the current workflow, and additional types of data released.



Home page of the U.S. Geological Survey Oceanographic Time-Series Data Collection. The horizontal navigation bar provides navigation between sections, and the interactive map allows users to easily browse the data holdings and identify sites of interest and view the types of data included in the datasets. On the map, the same icon is used for all platforms in an experiment; the legend of experiment names and icons is below the map. The boxes on the map indicate regional groupings of the experiments. Links to recent articles about the research are provided to the right of the map, selected publications associated with the data are provided on each experiment's description page.

The "Experiment List" tab links to a sortable table of information about the experiments: the name, title, date, Principal Investigator (PI), region, and link to the experiment's description page. This table is particularly useful for finding the most recent experiments or ones conducted by a particular scientist.

The example image below displays sites that were part of the Fire Island experiments from 2012 (black stars) and 2014 (blue stars). To see this view, you would start on the main map and click and drag the cursor to zoom the map to south of Long Island, New York. Clicking on any site icon displays a pop-up window containing the experiment name, the platform ID, and the duration of the data at that site. In the example below, the experiment name is "Fire Island 2012," Mooring ID is 928, and the data was collected between January and February 2012. The "1 of 3" at the top left of the box indicates that more than one platform was deployed at the location. Clicking the arrow at the top right of the pop-up window will step through other platfoms at that location. Clicking on an experiment name displays a page with details about that experiment.

Each experiment has a page showing details about the data collected, and they all take the same form: a description of the experimental program, how long it lasted,

(Updated Website continued on page 5)

Zoomed-in view of the sites comprising the Fire Island 2012 (black stars) and 2014 (blue stars) experiments. The pop-up window (displayed by clicking the icon) contains information specific to the site selected.

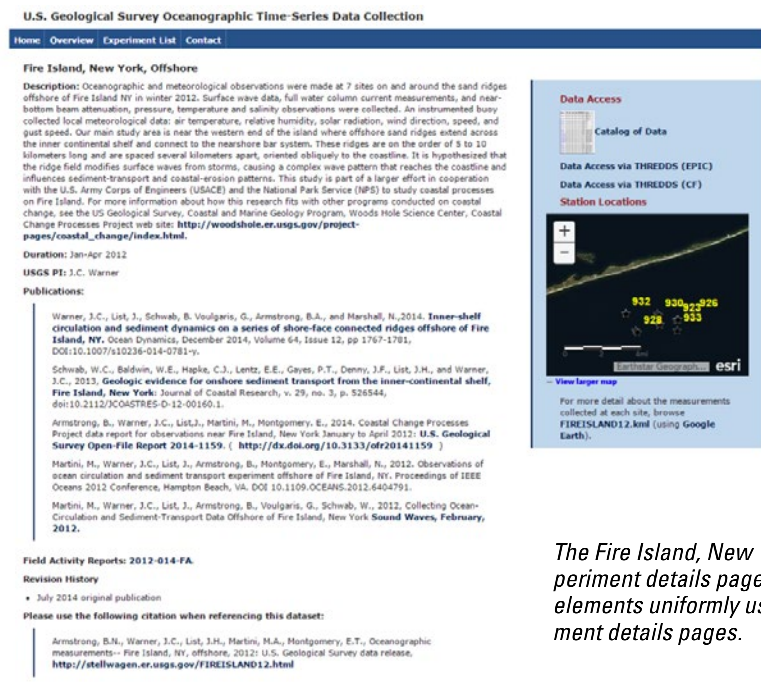
(Updated Website continued from page 4)

who conducted the study, related publications, field activity reports, release date, and data citation are on the left; data access links are in the blue panel at the right. For experiments that were assigned digital object identifiers (DOI) to permanently link to data, the experiment details page is the landing page for the DOI. A representative experiment page displaying the Fire Island New York Offshore experiment is shown at right.

In the blue side bar, the “Catalog of Data” link displays a table of the file name, position, depth, and kind of measurement. Clicking on the file name in the table downloads the file. The “Data Access via THREDDS” links provide access to the data in EPIC and CF compliant forms via OPeNDAP protocols. A lot more information about the data storage format, conventions, and protocols is available in the file format and access sections of Montgomery and others (2016).

The smaller map displays only the sites where measurements were made in this experiment, with their duration. Below the map is a link to a kml file (viewable in Google Earth) that displays the types of data from each sensor available at that site.

The updated website presents the locations of all the Coastal and Marine Geology Program oceanographic and estuarine datasets on one map. The map-based browsing capability makes it significantly easier and faster to identify the suitability of data in the collection for use in answering a variety of scientific and management questions. Visit the site at: **http://stellwagen.er.usgs.gov**.



U.S. Geological Survey Oceanographic Time-Series Data Collection

Home | Overview | Experiment List | Contact

Fire Island, New York, Offshore

Description: Oceanographic and meteorological observations were made at 7 sites on and around the sand ridges offshore of Fire Island NY in winter 2012. Surface wave data, full water column current measurements, and near-bottom beam attenuation, pressure, temperature and salinity observations were collected. An instrumented buoy collected local meteorological data: air temperature, relative humidity, solar radiation, wind direction, speed, and gust speed. Our main study area is near the western end of the island where offshore sand ridges extend across the inner continental shelf and connect to the nearshore bar system. These ridges are on the order of 5 to 10 kilometers long and are spaced several kilometers apart, oriented obliquely to the coastline. It is hypothesized that the ridge field modifies surface waves from storms, causing a complex wave pattern that reaches the coastline and influences sediment-transport and coastal-erosion patterns. This study is part of a larger effort in cooperation with the U.S. Army Corps of Engineers (USACE) and the National Park Service (NPS) to study coastal processes on Fire Island. For more information about how this research fits with other programs conducted on coastal change, see the US Geological Survey, Coastal and Marine Geology Program, Woods Hole Science Center, Coastal Change Processes Project web site: **http://woodshole.er.usgs.gov/project-pages/coastal_change/index.html.**

Duration: Jan-Apr 2012

USGS PI: J.C. Warner

Publications:

Warner, J.C., List, J., Schwab, B. Voulgaris, G., Armstrong, B.A., and Marshall, N.,2014. **Inner-shelf circulation and sediment dynamics on a series of shore-face connected ridges offshore of Fire Island, NY.** Ocean Dynamics, December 2014, Volume 64, Issue 12, pp 1767-1781, DOI:10.1007/s10236-014-0781-y.

Schwab, W.C., Baldwin, W.E., Hapke, C.J., Lentz, E.E., Gayes, P.T., Denny, J.F., List, J.H., and Warner, J.C., 2013, **Geologic evidence for onshore sediment transport from the inner-continental shelf, Fire Island, New York**: Journal of Coastal Research, v. 29, no. 3, p. 526544, doi:10.2112/JCOASTRES-D-12-00160.1.

Armstrong, B., Warner, J.C., List,J., Martini, M., Montgomery. E., 2014. Coastal Change Processes Project data report for observations near Fire Island, New York January to April 2012: **U.S. Geological Survey Open-File Report 2014-1159**. (**http://dx.doi.org/10.3133/ofr20141159**)

Martini, M., Warner, J.C., List, J., Armstrong, B., Montgomery, E., Marshall, N., 2012. Observations of ocean circulation and sediment transport experiment offshore of Fire Island, NY. Proceedings of IEEE Oceans 2012 Conference, Hampton Beach, VA. DOI 10.1109.OCEANS.2012.6404791.

Martini, M., Warner, J.C., List, J., Armstrong, B., Voulgaris, G., Schwab, W., 2012, Collecting Ocean-Circulation and Sediment-Transport Data Offshore of Fire Island, New York **Sound Waves, February, 2012.**

Field Activity Reports: 2012-014-FA

Revision History

- July 2014 original publication

Please use the following citation when referencing this dataset:

Armstrong, B.N., Warner, J.C., List, J.H., Martini, M.A., Montgomery, E.T., Oceanographic measurements-- Fire Island, NY, offshore, 2012: U.S. Geological Survey data release, **http://stellwagen.er.usgs.gov/FIREISLAND12.html**

Data Access

Catalog of Data

Data Access via THREDDS (EPIC)

Data Access via THREDDS (CF)

Station Locations

932 930 923 926 928 933

esri

View larger map

For more detail about the measurements collected at each site, browse **FIREISLAND12.kml** (using **Google Earth**).

The Fire Island, New York, Offshore experiment details page shows the layout elements uniformly used on all experiment details pages.

References:

- Montgomery, E.T., Martini, M.A., Lightsom, F.L. and Butman, Bradford, 2016, Documentation of the U.S. Geological Survey Oceanographic Time-Series Measurement Database (ver 2.0, April 2016): U.S. Geological Survey Open-File Report 2007–1194, **http://dx.doi.org/10.3133/ofr20071194**. ❁

Data from Three Recent Studies Released in the USGS Oceanographic Time-Series Data Collection

By Ellyn Montgomery

Oceanographic time series data from experiments in Chincoteague Bay, Maryland/Virginia; Barnegat Bay, New Jersey; and two coastal estuaries in southern California were released in the USGS Oceanographic Time-Series Data Collection at **http://stellwagen.er.usgs.gov** in early 2016 (see previous story). The experiments in Barnegat and Chincoteague Bays were conducted in 2014 and 2015 as part of the Estuarine Physical Response to Storms project **(http://woodshole.er.usgs.gov/project-pages/estuarine-physical-response/**). The experiments in southern California were part of a related study conducted between August 2013 and July 2015 in collaboration with the USGS Western Ecological Research Center. More details about these studies are provided at **http://woodshole.er.usgs.gov/project-pages/estuaries**.

***Neil Ganju** and **Patrick Dickhudt** prepare a bottom-mounted current meter for deployment in Barnegat Bay, New Jersey.*

Oceanographic and water-quality measurements in Barnegat Bay, New Jersey, 2014–2015

Water flow, water quality, and turbidity observations were collected at two sites in tidal wetland channels of Barnegat Bay, New Jersey, between August 2014 and July 2015 to characterize sediment fluxes to salt marshes. Two platforms were deployed at each of two sites for sequential time periods (August–October and

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October–January). The platforms were removed in January to prevent damage from freezing and a single platform was re-deployed at each site from April to July. The photo (page 5, bottom) shows one of the bottom platforms being prepared for deployment.

The citation with links to the data for this experiment is:

- Suttles, S.E., Ganju, N.K., Dickhudt, P.J., Montgomery, E.T., Borden, Jonathan, Martini, M.A., and Brosnahan, S.M., 2015, Oceanographic and water-quality measurements in Barnegat Bay, NJ, 2014: U.S. Geological Survey data release, **http://dx.doi.org/10.5066/F7CN71Z6**.

Oceanographic and water quality measurements in Chincoteague Bay, Maryland/Virginia, 2014–2015

Wave, water speed, water quality, and turbidity observations were collected at multiple sites in Chincoteague Bay, Maryland/Virginia, between August 2014 and July 2015. The platforms were removed, refurbished, and replaced several times during the deployment to achieve high sample rates from the available on-board power. The complete time-series at a site is comprised of ‘A’, ’B’, ’C’, and in some cases ‘D’ temporal sections. Given the more southerly location of this experiment, the platforms were deployed throughout the winter, but there was some data loss due to ice formation. Complementary meteorological observations were acquired to provide accurate atmospheric forcing data. The photo at left shows **Neil Ganju** preparing to refurbish one of the Chincoteague Bay platforms in January 2014.

***Neil Ganju** prepares to anchor the work boat at a site in Chincoteague Bay, Maryland.*

***Kat Powelson** and **Patrick Dickhudt** deploy an upward-looking current sensor in the marsh at Seal Beach, California.*

The citation with links to the data for this experiment is:

- Suttles, S.E., Ganju, N.K., Dickhudt, P.J., Brosnahan, S.M., Montgomery, E.T., Borden, Jonathan, and Martini, M.A., 2016, Oceanographic and water-quality measurements in Chincoteague Bay, Maryland, 2014-2015: U.S. Geological Survey data release, **http://dx.doi.org/10.5066/F7DF6PBV**.

Oceanographic and water quality measurements in two southern California coastal wetlands, 2013–2014

A related study in southern California compared an urbanized wetland with limited sediment supply at Seal Beach National Wildlife Refuge to a less modified marsh at Point Mugu. Instrumented platforms were initially deployed at Point Mugu between April and November 2013. In November the platforms were recovered, refurbished, and moved to Seal Beach to collect more data between November 2013 and May 2014. Water flow and turbidity measurements were made to constrain sediment fluxes within these marsh systems. The photo above shows a bottom platform with an upward-looking current sensor being deployed.

The citation and link to this data is:

- Ganju, N.K., Dickhudt, P.J., Montgomery, E.T., and Brosnahan, S.M., 2016, Oceanographic and water-quality measurements in two Southern California Coastal Wetlands, 2013-2014: U.S. Geological Survey data release, **http://dx.doi.org/10.5066/F78050PZ**.

Maps of the station locations for these and other experiments conducted by the Coastal and Marine Geology program may be viewed at the USGS Oceanographic Time-Series Data Collection website at **http://stellwagen.er.usgs.gov**. The data files are provided in EPIC (Equatorial Pacific Information Collection) compliant netCDF (network Common Data Format, **https://www.unidata.ucar.edu/software/netcdf/docs/**) and CF (Climate and Forecast, **http://cfconventions.org**) compliant forms. More detail about how we use netCDF in our data files is provided in the netCDF sections of Montgomery and others (2016, **http://woodshole.er.usgs.gov/pubs/of2007-1194/index.html**). ❁

First USGS Coastal Maps from Unmanned Aerial Systems

By Chris Sherwood

*The mapping team in front of the old Coast Guard Station at Cape Cod National Seashore. Left to right: **Michael Klinker**, **Conor Cullinane**, **Mark Klinker**, and **Nikhil Vadhavkar** (all from Raptor Maps, Inc.); **Barry Irwin** (USGS); E**ddie Obrupta** (Raptor); **Rob Thieler** (USGS); and **Chris Sherwood** (USGS). Not shown: **Mark Adams** (National Park Service), and the USGS surveying team: **Jon Borden**, **Sandy Brosnahan**, **Nick DiCosmo**, and **Alex Nichols**. Photo credit: **Dann Blackwood**, USGS.*

The USGS Coastal and Marine Geology Program made another technological step forward and produced two high-quality maps of coastal regions in Cape Cod, Massachusetts, using photogrammetry from images taken by unmanned aerial systems (UAS).

On March 1, 2016, a long permitting and planning process culminated with two UAS flights to map Coast Guard Beach in Cape Cod National Seashore. The project was a proof-of-concept exercise to demonstrate that UAS operations could be safely, legally, and effectively used to make maps of coastal features. The project was supported by the USGS Innovation Center for Earth Sciences and two ongoing Coastal and Marine Geology Program projects.

Coastal change is episodic. Significant changes in the beach and nearshore regions; erosion of dunes, bluffs, and cliffs; overwash; inlet formation; and changes in habitat occur in a matter of hours during storms. Major geomorphic changes can occur with only 24 to 48 hours advance notice, often after long periods of relatively slow change.

Prediction of storm impact in coastal regions requires accurate and up-to-date maps of coastal morphology on land (bluff or dune height, beach slope and width) and in the water (nearshore bars and shoals, offshore bathymetry). Evaluation of geomorphic response models requires accurate maps of the same features immediately after the events, before anthropogenic or natural fair-weather processes modify the storm-related changes. Thus, the ability to map before and after infrequent but significant events is critically important.

Structure-from-motion is a new but proven technique for making high-resolution maps from multiple photographic images. Structure-from-motion uses automatic point matching and least-squares fitting to reconstruct a three-dimensional scene from a set of images from different camera locations. Unmanned aerial systems provide the ability to acquire these images and map coastal features quickly, safely, and inexpensively, on short notice, and with minimal impact. By contrast, lidar surveys of coastal regions are infrequent and costly: the most recent measurements on Cape Cod were obtained in 2011, and logistics prevented timely mapping after the series of winter storms that occurred in January and February 2015.

Permits and planning documents from the National Park Service and the U.S. Department of the Interior were required prior to the flights. While the USGS is authorized to fly UAS under the terms of a Memorandum of Understanding with the Federal Aviation Administration (FAA), which provides a Certificate of Authorization, the USGS UAS team was busy, so we hired Raptor Maps, Inc., to fly and acquire the imagery. Contractors can now fly under a Section 333 Exemption from the FAA, which means that the USGS can take advantage of UAS techniques in many coastal regions.

Raw data from the UAS flights consist of thousands of high-resolution digital images, tens of surveyed ground control points, and about 100 independent surveyed points for comparison. The primary products from photogrammetry are point clouds containing hundreds of millions of georeferenced x, y, z points with associated RGB (red-green-blue) color values. These point clouds are similar to those generated by lidar surveys, and can be stored in the same formats and processed with the same software tools.

(Unmanned Aerial Systems continued on page 8)

*The Raptor Maps, Inc. X8 fixed-wing unmanned aerial system deploying its parachute at the end of the second mission. The first mission lasted 70 minutes and flew at about 120 meters above ground level with two 14 megapixel cameras. The second mission flew lower and longer (90 minutes), and mapped the same region with a near-infrared camera. Photo credit: **Dann Blackwood**, USGS.*

((Unmanned Aerial Systems continued from page 7)

Mapping one of the targets used as a ground control point. Left to right: ***Rob Thieler, Sandy Brosnahan, Alex Nichols****. Photo credit:* ***Dann Blackwood****, USGS.*

Final products include digital elevation models (DEM) and georeferenced mosaics of the images.

One of the objectives of this study was to determine just how accurate these maps are. It turns out that, given adequate ground control, the maps can be very accurate. **Barry Irwin** walked transects on the beach and measured elevation at about 140 independent points with a precision of +/- 2 centimeters (cm) using differential GPS while the UAS were flying. These points were compared with the closest points on the DEM produced from the UAS imagery. More than 90% of the points agreed to within +/- 15 cm, and most (>80%) agreed to within +/- 10 cm. However, in regions with no ground control, the DEM tended to drift away from ground truth elevation values and was off by as much as 0.6 meters until corrected with ground control points based on earlier lidar surveys. This requirement for extensive ground control is one of the tradeoffs associated with structure-from-motion methods, however, in many cases, it is off-

Mark Klinker *(Raptor Maps, Inc.) recovers the UAS after the first flight. Photo by* ***Dann Blackwood,*** *USGS.*

View looking south across Nauset Marsh as ***Barry Irwin*** *and* ***Sandy Brosnahan*** *set up the differential global positioning system on the lawn of the old Coast Guard Station, Cape Cod National Seashore. Photo credit:* ***Chris Sherwood****, USGS.*

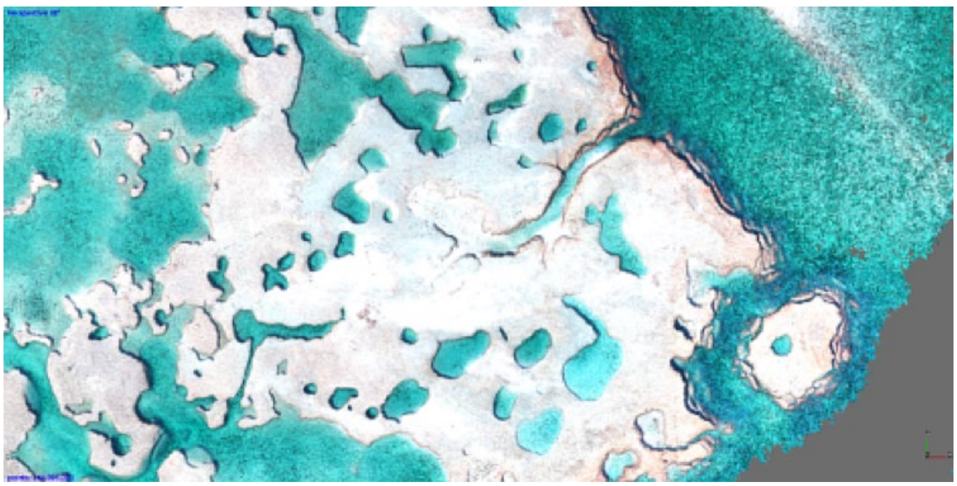
Michael Klinker *(left) and* ***Mark Klinker*** *(right; both from Raptor Maps, Inc.) preparing to launch the UAS from the old Coast Guard station, Cape Cod National Seashore. Photo credit:* ***Dann Blackwood****, USGS.*

Barry Irwin *and* ***Sandy Brosnahan*** *set up the differential global positioning system on the lawn of the old Coast Guard Station, Cape Cod National Seashore. Photo credit:* ***Chris Sherwood****, USGS.*

(Unmanned Aerial Systems continued on page 9)

(Unmanned Aerial Systems continued from page 8)

Screenshot of the dense point cloud consisting of 430 million georeferenced, colored points derived from the rgb (red-green-blue) UAS images. The blue flags indicate ground control points used to constrain the photogrammetric reconstruction.



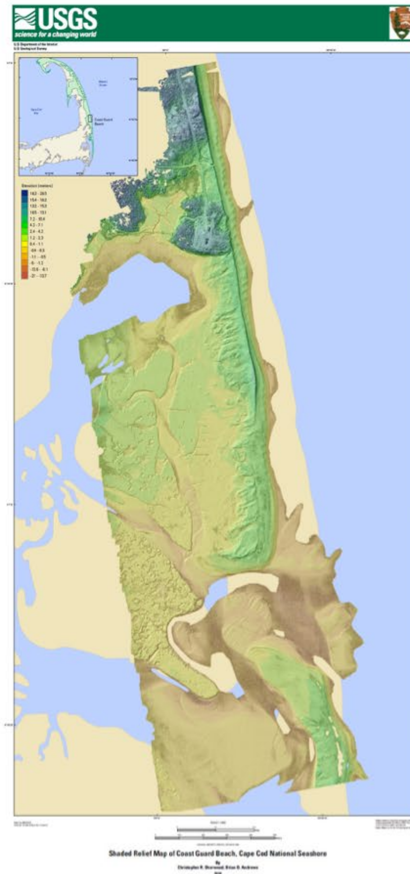
Detail of the near-infrared point cloud over a portion of Nauset Marsh. The faint reddish tinges are the first glimmer of spring growth at the edges of the marsh.

set by the low cost and rapid turnaround time associated with UAS data collection.

In addition to the studies in Cape Cod National Seashore, we worked with collaborators and contractors to make multiple maps of Sandwich Town Neck Beach, Massachusetts. Repeat mapping there has allowed us to document changes associated with both natural events and beach nourishment projects. The maps made with UAS images provide us with data needed to evaluate numerical models of coastal geomorphological change.

Acknowledgments

We are grateful to the National Park Service, and particularly **George Price** (Superintendent of Cape Cod National Seashore) and his staff members **Sophia Fox** and **Mark Adams**, for permission to fly in the park and help with permits and logistics. Thanks also to the Town of Eastham, the Eastham Conservation Foundation, and the Massachusetts Audubon Society for permission to overfly their private parcels in the study area. We also thank **Jeff Sloan** and **Bruce Quirk** of the USGS UAS team. The project was supported by the USGS Innovation Center for Earth Sciences (**http://geography.wr.usgs.gov/ICES/**) and two ongoing USGS Coastal and Marine Geology Program projects: the Barrier Island Evolution Project (**http://coastal.er.usgs.gov/bier/**) and the Coastal Model and Field Measurements project (**http://woodshole.er.usgs.gov/project-pages/coastal_model/**). ❆

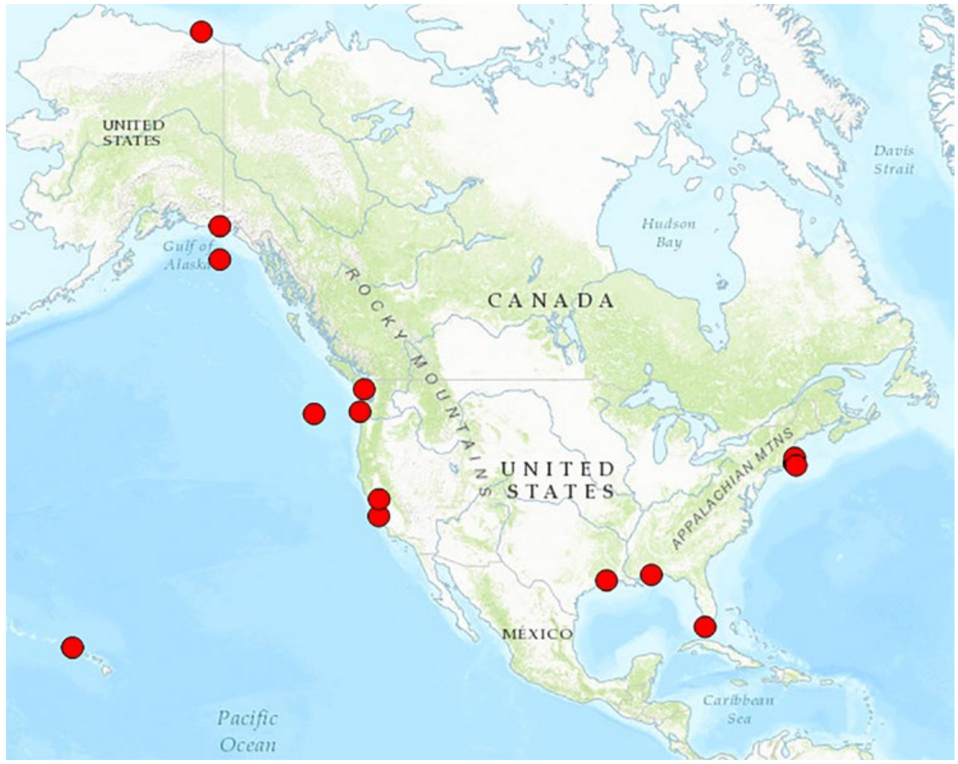


Preliminary map products derived from the UAS imagery collected near Coast Guard Beach, Cape Cod National Seashore on 1 March 2016. Top: shaded relief color contoured digital elevation map on a 0.1-meter grid. Bottom: orthophotomosaic (0.05-meter resolution) overlaid on the shaded relief map.

Future Fieldwork, August-September 2016

By Rex Sanders

USGS scientists plan to visit more than 20 locations in August and September 2016, studying estuaries, post-dam river recovery, hydrothermal vents, and much more. Here's a quick preview of some coastal and offshore fieldwork scheduled by our researchers. Plans could change at any time.



Approximate locations of some planned USGS coastal and offshore fieldwork in August and September 2016. Image from ***http://coastalmap.marine.usgs.gov/***.

- **Carmel River, California:** Measure river channel topography and turbidity, and take photos following dam removal, January 1–December 31, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-638-FA**
- **Cape Cod, Massachusetts:** Collect water samples, marsh cores and time series water quality and flow data from Sage Lot Pond, April 8–November 30, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-015-FA**
- **Cape Cod, Massachusetts:** Examine the environmental geochemistry and health of 11 estuaries, April 11–November 30, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-016-FA**
- **Barter Island, Alaska:** Measure permafrost temperature, collect time lapse images of coastal change, and measure subsurface geology, May 20–September 30, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-645-FA**
- **Sacramento-San Joaquin Delta, California:** Time series measurements of suspended sediment, tides, and waves for habitat restoration, June 7–August 19, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-646-FA**
- **Kauai, Hawaii:** Collect oceanographic, geologic, hydrologic, and biologic data to evaluate links between circulation, groundwater flow into the ocean, and coral disease, June 29–August 5, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-631-FA**
- **Offshore Oregon and Washington:** Study hydrothermal vent fields and associated organisms on Gorda and Juan de Fuca Ridges, July 26–August 4, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-657-FA**
- **Kauai, Hawaii:** Collect sediment samples from seven north shore watersheds, July 29–August 3, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-630-FA**
- **Grand Bay, Alabama and Mississippi:** Evaluate sediment dynamics and sediment fluxes in the estuary, August 1–10, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-034-FA** and **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-348-FA**
- **Icy Bay, Alaska:** Map subduction zone faults using multichannel seismic reflection, and collect high-resolution bathymetry in Taan Fjord, site of a recent large landslide and tsunami, August 2–17, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-654-FA**
- **Gulf of Alaska:** Map the Queen Charlotte–Fairweather Fault zone to constrain earthquake hazards using high-resolution multichannel seismic reflection, August 7–26, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-656-FA**
- **Louisiana and Texas coastline:** Collect bathymetry and sub-bottom profiles from Marsh Island to Sabine Pass, August 8–September 16, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-339-FA**
- **Sacramento-San Joaquin Delta, California:** Time series measurements of suspended sediment, tides, and waves for habitat restoration, August 8–October 14, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-662-FA**
- **Florida Keys:** Collect coral reef cores to measure trends in Holocene reef development, August 15–26, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-332-FA**

(Future Fieldwork continued on page 11)

(Future Fieldwork continued from page 10)

- **Columbia River mouth area, Oregon and Washington:** Collect bathymetry and topography along the changing coast, August 15–September 2, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-663-FA**
- **North of Cape Cod, Massachusetts:** Collect seabed sediment samples for geologic mapping, September 9–20, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-038-FA**
- **Nantucket Sound, Massachusetts:** Characterize the seafloor and sediment grain size for coastal management and geologic framework studies, September 12–24, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-011-FA**
- **Elwha River, Washington:** River channel topographic surveys and sediment sampling after dam removal, September 20–25, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-651-FA**
- **Elwha River, Washington:** Monitor changes in the river, estuary, and nearshore after dam removal, September 27–October 3, 2016. Details at **http://cmgds.marine.usgs.gov/fan_info.php?fan=2016-664-FA**

For a complete list of past, present, and future USGS Coastal and Marine Geology program fieldwork, see: **http://cmgds.marine.usgs.gov**. ❁

Outreach

USGS Science Center Increases Support of USF Oceanography Camp for Girls

By Kira Barrera

Each summer the USGS St. Petersburg Coastal and Marine Science Center sponsors the University of South Florida (USF) Oceanography Camp for Girls, a three-week summer program developed in the 1990s to inspire and motivate young women entering high school to consider career opportunities in the sciences. During the camp the young women go on a research cruise aboard the R/V *Bellows*, learn about fieldwork techniques and laboratory procedures, and collect field survey data for research projects. This summer marked the 17th year of USGS involvement with the camp and the St. Petersburg Coastal and Marine Science Center took its support to new levels.

Oceanography Camp For Girls campers tour the USGS St. Petersburg Coastal and Marine Science Center.

Kira Barrera, a physical scientist and the center's outreach and education coordinator, served as a science mentor for the camp and led two ocean acidification research projects. The projects were conducted at Clam Bayou, a local nature preserve on Boca Ciega Bay and the site of the USF College of Marine Science (CMS) Clam Bayou Education Center and the USF–CMS Coastal Ocean Monitoring and Prediction System (COMPS) station for the West Florida Shelf. Over four days, the campers explored how ocean acidification is affecting the world's oceans, and is occurring at different rates locally due to many factors such as ecosystem structure and dynamics. The campers collected water temperature and salinity data from various environments at Clam Bayou, utilized narrow and broadband spectrophotometric and electrode analysis of pH, and analyzed and compared their data to the historical and diurnal data collected by the COMPS station.

An annual highlight of the camp are the tours of the center, which took place over two days and allowed the young women to observe laboratory procedures and analysis as well as demonstrations with a variety of scientific instruments, equipment, and research vessels. The tour culminated with career interviews of scientists **Alisha Ellis**, **Elsie McBride**, **Legna Torres**, **Chris Smith**, **Karen Morgan**, **R.C. Mickey**, **Ginger Range** and **Hilary Stockdon**.

(Oceanography Camp continued on page 12)

(Oceanography Camp continued from page 11)

*Campers conduct water quality sampling at Clam Bayou with **Kira Barrera**.*

The camp's opening and closing ceremonies were held at the USGS. Campers and their families enjoyed the opportunity to visit the center. All the campers shared the results of their research projects through verbal and poster presentations at a closing ceremony. The posters were then displayed in the center lobby. ❆

***Nick Zaremba** and **Chelsea Stalk** demonstrate sediment core processing.*

Research project posters created by Oceanography Camp for Girls campers were displayed in the USGS St. Petersburg Coastal and Marine Science Center lobby.

Staff and Center News

USGS Student Trainee Studies Effects of Wave Energy on a Salt Marsh Boundary

By Ann Marie Luppino

Since 2015, **Ann Marie Luppino**, a senior from the Environmental Science and Technology program at Upper Cape Cod Regional Technical School, has been working for the USGS Coastal and Marine Geology Program in Woods Hole, Massachusetts (Mass.). She is a student trainee member of the sediment transport department and is supervised by electronics engineer **Marinna Martini**. Ann Marie is part of a cooperative-learning program with her school that allows her to replace every other week of classroom work with an internship from the outside community, to gain hands-on experience toward a possible career.

During Ann Marie's time with the USGS, her tasks have included equipment maintenance, instrument programming, and fieldwork. During the summer of 2015, Ann Marie assisted in different field projects, including helping with tunicate and salt marsh vegetation studies, demonstration deployments of an autonomous mapping vehicle (jet-yak), and collecting salt marsh sediment cores. She assisted with unmanned aerial system surveys that began in December 2015 at Town Neck Beach in Sandwich, Mass., to document and quantify erosion. Each fieldwork opportunity has given her insight into how studies are conducted from start to finish.

Ann Marie developed a senior project combining the skills she learned through high school and her experience working at USGS; the title is "The Effects of Waves in Relation to Salt Marsh Erosion." Globally, salt marshes are being lost to sediment erosion, changes in land use, higher sea levels, nutrient input, and other factors. Their vulnerability is related to sediment availability because marshes accrete vertically, in part due to deposition of suspended sediment on the marsh surface. Ann Marie's hypothesis states that if waves flow toward a salt marsh at a high velocity, the salt marsh will erode at a greater rate, removing sediment from the marsh system and increasing vulnerability. This prediction is based on the understanding that when high-energy waves come into contact with sediment, the repeated force of the waves weakens the stability of the marsh, resulting in erosion and lack of deposition.

Ann Marie was assisted in her efforts by scientists at USGS. **Neil Ganju**, an oceanographer with the USGS, helped design the project. Ann Marie and Neil brainstormed possible project ideas, identified a field site in Wareham, Mass., and developed a problem statement and hypothesis around salt marsh erosion. **Steve Suttles**,

(Wave Energy continued on page 13)

Maps showing the location of site 1 and site 2 for the two-month time span of fieldwork for the project.

(Wave Energy continued from page 12)

a civil engineer that works in the sediment transport department for the USGS, also assisted Ann Marie for the duration of the project. Steve helped download and analyze data when needed, and taught Ann Marie how to use an RBR D-Wave instrument (a low frequency data logger designed for unattended measurement of waves). When installing instrumentation in the marsh, Ann Marie was assisted by **Sandy Brosnahan**, a geochemistry technician with the USGS.

The project was designed to measure the salt marsh erosion from the effects of wave activity along the coast. RBR D-Wave instruments were placed in the water at two locations offshore of the salt marsh in Parkwood Beach, Wareham, Mass., to measure wave heights. Each instrument was weighted and attached to a rope that led to a chain as a support anchor. A PVC pole marked the location on shore. At each location, six metal rods were pounded into the salt marsh face horizontally. They were evenly spaced and inserted into the marsh with 88 centimeters (cm) of the rod buried and 18 cm left exposed. Erosion was measured every two weeks over a two-month period by measuring the exposed portion of the rods. The instrumentation was in the marsh from November 12, 2015 to January 12, 2016.

Ann Marie Luppino *recording GPS coordinates for her senior research project.*

Ann Marie Luppino *measuring amount of erosion rate at site 2 by measuring the exposed portion of the rod.*

The data collected supports the hypothesis; at site 1, there was less wave activity and a low average erosion rate; at site 2, where there was more wave activity, there was a greater average erosion rate. This project can now be repeated to retest the hypothesis and evaluate results in other locations. Ann Marie will continue to work with the USGS until August 2016 when she goes to college. ☸

Ann Marie Luppino *measuring the amount of erosion at site 1 by measuring the exposed portion of the rod.*

RBR D-Wave instrument mounted to weights and ready to be deployed to measure wave height.

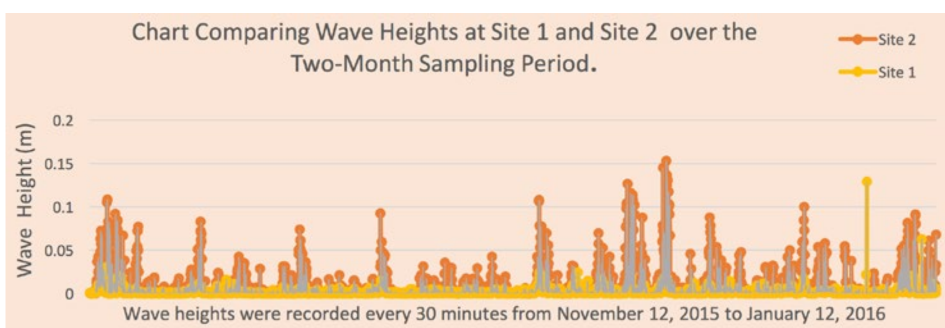


Chart comparing wave heights at the two sites over the two-month sampling period.

Mean wave height and average erosion for November 2015 to January 2016		
	Site 1	Site 2
Mean Wave Height	0.002 meters	0.01 meters
Average Erosion	9.16 centimeters	10. 3 centimeters

Table showing the study results from the two-month sampling period.

New Review Paper on the Conservation of Western Atlantic Coral Reefs

By Ilsa Kuffner

Research marine biologist **Ilsa Kuffner** and Mendenhall Fellow **Lauren Toth** of the USGS St. Petersburg Coastal and Marine Science Center published a review article entitled "A geological perspective on the degradation and conservation of western Atlantic coral reefs" in the resource-management focused journal, *Conservation Biology*. The article highlights the importance of geologic processes and geomorphologic structure of reefs in providing ecosystem services such as coastline protection and habitat for fisheries.

The authors' aim in writing this paper was to raise awareness among ecologically focused reef managers and conservationists of processes that often go unappreciated because they occur more slowly than can be noticed easily by human observers. Processes like physical and biological erosion (see coral photo, right), sediment production and transport, and reef construction and cementation are difficult but important to measure.

Ecological monitoring programs on coral reefs traditionally focus on the thin, living veneer of the reef, carefully quantifying the extent of cover by animals and plants, but rarely quantify loss of reef structure or framework destabilization. The USGS Coastal and Marine Geology Program is helping achieve a more effective and balanced approach to assessing and managing coral reefs through investigations of physical (**http://soundwaves.usgs.gov/2014/06/research3.html**), biogeochemical (**https://www2.usgs.gov/blogs/features/usgs_top_story/mangroves-protecting-corals-from-climate-change/**), and geological (**http://soundwaves.usgs.gov/2013/08/research2.html** and **http://coastal.er.usgs.gov/crest/research-themes/holocene.html**) reef processes.

Managing reefs with respect to physical resilience, in addition to ecological resilience, could optimize the expenditure of resources in conserving coral reefs and the services they provide.

The full citation for the review paper is:

Kuffner, I.B. and Toth, L.T., 2016, A geological perspective on the degradation and conservation of western Atlantic coral reefs. *Conservation Biology*, in press, DOI: 10.1111/cobi.12725.

The paper is available for open-access download at: **http://onlinelibrary.wiley.com/doi/10.1111/cobi.12725/abstract**. ❁

A coral on a Florida Keys reef severely undercut by the process of bioerosion, mostly the work of parrotfish and boring sponges. This coral colony is about the size of an exercise ball and is estimated to be around 100 years old. Over its lifetime, the coral contributed approximately 120 kilograms (264 pounds) of calcium carbonate rock to the reef. Photo credit: ***Ilsa Kuffner****.*

Polar Bear Outlook Favorable Under Certain Scenarios

By Jolene Gittens

A new USGS study, “Forecasting the relative influence of environmental and anthropogenic stressors on polar bears,” (**http://dx.doi.org/10.1002/ecs2.1370**) finds that aggressive greenhouse gas mitigation could greatly reduce the chance of a substantial decline in the worldwide polar bear population.

The study, an update to the 2015 publication “Evaluating and Ranking Threats to the Long-Term Persistence of Polar Bears,” uses a Bayesian network model to evaluate the relative influence of environmental and anthropogenic stressors and their mitigation on the persistence of polar bears. Overall sea ice conditions, affected by rising global temperatures, were found to be the most influential determinant of population outcomes:

- An unabated rise in atmospheric greenhouse gas concentrations was the dominant influence leading to worsened population outcomes, with polar bears in three of four ecoregions reaching a dominant probability of decreased or greatly decreased population by the latter part of this century.
- Stabilization of atmospheric greenhouse gas concentrations by mid-century delayed populations reaching a greatly reduced state by approximately 25 years in two ecoregions.
- Prompt and aggressive mitigation of emissions reduced the probability of any regional population becoming greatly reduced by up to 25%.

Marine prey availability, which is closely linked to sea ice condition, had slightly less influence on outcome state than sea ice availability itself. Reduced mortality from hunting and defense of life and property interactions resulted in modest declines in the probability of decreased or greatly decreased population outcomes. Minimizing other stressors such as trans-Arctic shipping, oil and gas exploration, and contaminants had a negligible effect on polar bear outcomes.

The study found that long-term conservation of polar bears would be best supported by holding global mean temperature to ≤ 2°C above preindustrial levels. Until further sea ice loss is stopped, management of other stressors may serve to slow the transition of populations to progressively worsened outcomes, and improve the prospects for their long-term persistence.

The full citation for the article is:

- Atwood, T. C., Marcot, B. G., Douglas, D. C., Amstrup, S. C., Rode, K. D., Durner, G. M. and Bromaghin, J. F., 2016, Forecasting the relative influence of environmental and anthropogenic stressors on polar bears. *Ecosphere*, 7:e01370, doi:**10.1002/ecs2.1370**. ❆

Adult female polar bear and her cub photographed near the community of Kaktovik, Alaska, in September 2015.

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